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# VAPOR DEPOSITION DEVICE
[JOCHAKU SOCHI]

Kiyohiro Kawasaki

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| INVENTOR | (72): | KAWASAKI; KIYOHIRO |
| APPLICANT | (71): | MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD. |
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Specifications

1. Title of the Invention

Vapor Deposition Device

2. Claim(s)

A vapor deposition device characterized by being provided with a function for irradiating a reaction space with light and detecting the scattered light from fine particles in the reaction space.

3. Detailed Specifications

The present invention relates to a vapor deposition device, and an object is to enable estimation of a semiconductor device yield by measuring the number of fine particles adhered and formed during vapor deposition.

There are numerous vapor deposition means, such as vacuum, sputtering, and plasma vapor deposition, which are selected by considering physical damage of the target used for vapor deposition and depending on the physical and chemical properties of each vapor deposition material. A vacuum reaction chamber is the common point in these vapor deposition methods. Figure 1 shows a schematic diagram of a sputtering device; its reaction chamber comprises an upper lid or a bell jar **1** and a gutter-like chamber **2** and it is blocked from the outside air by an o-ring **3** made of rubber or the like. The reaction chamber is decompressed by a vacuum-generating mechanism, such as a rotary pump **4**. A dispersion pump or ion pump can be jointly used when a higher degree of vacuum is required. **5** is a valve which connects the reaction chamber to the vacuum generating mechanism; **6** is a leak valve [misspelled in source] used when releasing a vacuum. **13** is a reaction gas supply valve; the reaction gas is suitably selected and mixed by various

gas sources **7** to **9** and valves **10** to **12**. **14** is a target and **15** is a substrate; a DC or AC voltage is applied across the aforesaid **14** and **15** from a power source **16**. **17** and **18** are water-cooling pipes for cooling the target and substrate, respectively, to prevent an abnormal temperature rise by close contact with the target or substrate or by passing the target or substrate. Conversely, it is necessary to keep the substrate **15** at a certain constant high temperature, and in this case, a heater or lamp used for heating the substrate is installed in the reaction chamber. **19** is an insulation plate made of quartz or the like, and even though contamination of a specimen **20** to be vapor-deposited by the substrate **15** is prevented by separating the specimen **20** from the substrate **15** by an insulation plate of quartz or the like, the insulation plate is usable only for AC sputtering and not for DC sputtering.

For example, Ar (argon) is used as the reaction gas when the degree of vacuum is 1 Torr and the distance between the electrodes (between the target and substrate) is 6 cm. If the substrate **14** is Al (aluminum), the Al is vapor-deposited on the specimen **20** at a growth rate of 20 to 25 Å /sec. by glow discharge at a voltage of 500 V and a current density of 1.3 $mA/cm^2$. This vapor deposition mechanism accelerates the Ar ions in a cathode dark space ionized by glow discharge and in order to bombard the target, the Al atoms constituting the target are ionized on the target surface, fly out, reach the specimen **20**, lose kinetic energy, and the Al starts to crystallize.

Higher densification and higher integration of semiconductor devices have advanced even further. Then if refinement of Al wire used for the

metal wiring path is considerable—to a line width of 2 to 3 μm, it is anticipated that a line width of about 0.5 μm can be attained by electron beam exposure. In LSI and VLSI, an extremely satisfactory film quality is required for the adhesion quality of Al, Poly Si or the like to meet such finer patterning. That is, it is demanded that 1) there be no pinholes even if the film is thin, 2) step coverage be good, 3) the uniformity of the film thickness be good, 4) there be no sticking of foreign matter or the like, etc. The above-mentioned items 1) and 2) are important for LSI multilevel interconnection, and item 3) is required for increasing the accuracy of the pattern width obtained by etching. For item 4), the composition of the vapor deposition material sometimes varies and a lumpy adhering material is sometimes formed by an abnormal discharge, with dust or the like adhering to the specimen prior to vapor deposition as the nucleus.

A few causes of abnormal discharge have been considered. For example, it is thought that a conductive foreign matter mixes into the glow discharge, causing the temperature of the surface of the target to rise, and the target does not become a molecular gas by sputtering but scatters in the form of lumps of certain sizes, or the impurities contained in the target get mixed in the reaction space by sputtering.

When abnormal discharge occurs for any reason, the surface of the specimen is dotted with a lumpy adhering material. Because the size of this lumpy material is from several μm to several tens of μm and the thickness is several μm even when it has the same composition as the, e.g., target, it is impossible to perform patterning by etching, which brings about

critical results, such as a short-circuit in the Al wiring path, and markedly reduce the semiconductor integrated circuit yield because the wiring interval of the Al wiring path in LSI is 2 to 3 μm, as mentioned above, and the thickness of the Al layer is 1.5 μm at the most, so lumpy Al cannot be patterned by over-etching. And so, such a lumpy adherend could not be recognized if vapor deposition was not finished.

In view of the above-mentioned problems, the present invention prevents a lumpy substance from adhering on a specimen by optically detecting fine particles present in the reaction space thereon, which would become the cause of abnormal discharge. The practical examples of the present inventions will now be described along with the drawings.

Figure 2 is a cross section showing a practical example of the present invention. The upper lid or bell jar **1** is provided with a window **23** through which a parallel light beam **22** having a suitable beam width is transmitted from a light source **21**. Depending on their size, the fine particles **24** in the reaction space produce a scattered light **25** by varying the intensity of the dispersion. A window **26** is provided in a position where no parallel light beam **22** or reflected light is incidented into the vacuum chamber, and the aforesaid [misspelled in source] scattered light **25** is received by a detector **27** in which a photomultiplier is used as the light-receiving part. The fine particles **24** generally fly out quickly; hence, the scattered light **25** becomes pulse-like, and since the height of that pulse corresponds to the size of the fine particles **24**, the number of fine particles **24** can be measured by counting the number of pulse signals fetched by the detector **27** using a constant-time counter **28**, or by integrating them and

then recording and displaying them on a recorder **29**. The amplitude of the pulse signals also corresponds to the size of the fine particles **24**; hence, it is possible to classify how many fine particles having an average particle size of 0.5 μm or higher, 2 μm or higher, 5 μm or higher, and the like are produced by setting the amplitude level using the proper limiter circuit. Moreover, Fig. 3 is a schematic cross section showing a practical example of the present invention.

Because the continuous light emission accompanying the glow discharge of a reaction gas is incidented onto a photomultiplier in sputtering or plasma vapor deposition and the scattered light **25** from the fine particles **24** is faint, the particles are obscured by the light emission and difficult to detect. Therefore, the wavelength of the light source of the optical system and the wavelength of the glow discharge must be considered so that they differ in order to detect the particles. For example, since the glow discharge of Ar is primarily a blue emission of 4,000 to 5,000 Å, and if red light is used (6,000 to 7,000 Å) by combining an He-Ne laser (wavelength: 6,328 Å) with a white light source having a suitable filter as the light source used for detection, the separation of the light emission from the scattered light by glow discharge is facilitated. A high beam-splitting sensitivity close to the wavelength of the scattered light is used for the photomultiplier, and the scattered light must be detected through a suitable filter for eliminating the glow discharge light.

As seen from the above explanation, in addition to the vapor deposition device according to the present invention enabling detection of particles in a reaction space which are the source of a lumpy adherend on the surface

of a specimen and avoiding a situation in which the yield of a semiconductor device or the like is reduced, there is an outstanding advantage because the titled device can significantly contribute to maintaining the optimum vapor deposition conditions.

Moreover, DC sputtering of Al was used as a practical example, but since the gist of the present invention is to measure the atmosphere inside the reaction space near the specimen in which the material to be vapor-deposited becomes gaseous, the titled device also can be applied to a reactive sputtering of a polycrystalline or amorphous silicon, with, e.g., Si as the target and Ar as the reaction gas, or to a case in which polycrystalline or amorphous silicon is obtained by plasma vapor deposition by glow discharge, with $SiH_4$ and $H_2$ as the reaction gases. It is further applicable to a general CVD vapor deposition or the like by pyrolysis of $SiH_4$.

The usefulness of the present invention in plasma or CVD vapor deposition is obvious in considering that the desired vapor deposition material coagulates in the reaction space in the form of particles if the chemical reaction in the reaction space shifts greatly from equilibrium and they deposit on the specimen as a lumpy adherend if a target is not present and the material of a target does not fly out on the specimen.

4. Brief Explanation of the Drawings

Figure 1 is a schematic diagram of a sputtering device and Figures 2 and 3 show a ground plan and schematic diagram of a sputtering device provided with a detection function in a practical example of the present invention.

21: light source; 22: parallel light beam; 23: window; 24: fine particles; 25: scattered light; 26: window; 27: detector; 28: counter; 29: recorder

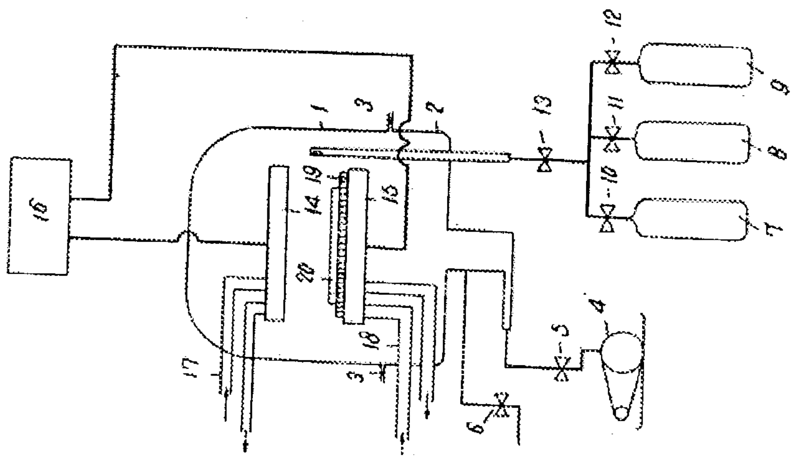

Figure 1

Figure 2

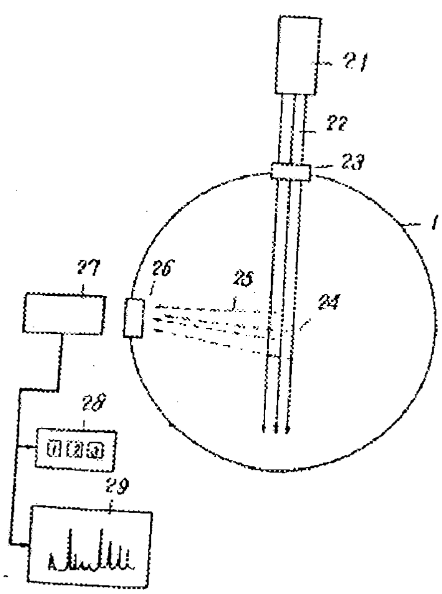


Figure 3